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Integrated Effect of Foliar Fertilization of Fe, Zn and Rates of P Fertilization on Growth and Yield of Cowpea

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ABSTRACT

At the Experimental Farm of Faculty of Agriculture, El-Mansoura University, Egypt, a field experiment was carried out, to investigate the effect of zinc and iron individually or mixed as foliar application on cowpea plant growth, chemical composition, yield and its components as well as availability of nutrients in the soil, all that under phosphorus application effect. The experiment was laid out in split plot design with three replicates, assigning twelve treatments consisting of three levels of phosphorus (50, 100 and 150% from recommended dose) as main plot, and four levels of micronutrients foliarly (without, Zn, Fe and Zn+Fe) as sub plot. As for the effect of P-fertilization, the results show that all treatments significantly increased vegetative growth (plant height (cm), no. of branches/plant, no. of leaves/plant), yield and its components (No. of pods/plant, No. of seed/pod, 100 seed weight g and Seed yield Kg/fed.) as well as chemical (N, P, K, Zn and Fe) and quality composition (chlorophyll content, c.protien, T. carbohydraties and C. fiber.). These effects were more obvious especially at higher concentrations of these treatments 150% RD except chlorophyll content, quality parameters with 100% RD. The highest mean values of available P, Zn and Fe in the soil were recorded for the plants treated with P-fertilization at the rate of 100% from recommended dose, whereas the lowest values of available N and K were realized for the same treatment. On the other hand, foliar application with micronutrient has a significant effect on cowpea growth. The highest values of parameters observed with the mix of (Zn+Fe) comparing with the untreated plant. Moreover, the mix of micronutrient (Zn+Fe) recorded the highest values of available P, Zn and Fe, whereas the highest values of available N and K were recorder with the untreated plant. The interaction effect between P fertilization and micro nutrients show a promotive effect on growth parameters with using mix of Zn+Fe. The highest mean values of parameters was recorded under 150% P from RD, whereas the highest mean values of chlorophyll content, quality parameters and available P, Zn and Fe recorded with 100% P from RD and the lowest values of available N and K were realized for the same treatment.

Keywords: phosphorus fertilization, zinc, iron, foliar application, cowpea.

INTRODUCTION

Legumes are considered the most important source of food after cereals in the world, as they are main sources of protein and energy for human. Currently, it can be a good alternative for animal protein. Due to nutrition values and economic importance, it is necessary to develop new methods for increasing the crop production. In addition, cowpea is the most important crop of legume family. The plant produces seeds containing18-32 % protein; as well as, nitrogen fixation ability. Therefore, it plays an important role in human nutrition and sustainable farming systems (Salih, 2013).

Plant nutrients are the main source for improving the quality and quantity of cowpea. The non-availability of nutrients is a major constraint of crop productivity and soil fertility, which imbalanced use of plant nutrients markedly affects the crop growth and yield (Siddiqui *et al.,* 2015). Phosphorus fertilizers seem to be an important constraint in bumper harvest of the crop in most of the cowpea growing areas which are deficient in phosphorus. The supply of phosphorus to legumes is more important than of nitrogen because, later being fixed by symbiosis with Rhizobium bacteria. Phosphorus stimulates nodulation, early root development, plant growth, yield and quality of grains etc. It gives rapid and vigorous start to plants, strengthens straw and decreases lodging tendency. Phosphorus application to legumes not only benefits the current crop but also favorably affects the succeeding non-legume crop. It also improves the crop quality and resistance against plant diseases. Availability of soil P is critical for growth and development of cowpea, and a poor P availability limits its productivity. Phosphorus deficiency is a critical nutrient-deficiency problem in the soils and may cause up to 29-45% yield losses in cowpea (Ahlawat *et al*., 2007).

Foliar spraying is a new technique for feeding crop, which liquid form of micronutrients are used to leaves (Nasiri *et al.,* 2010). Using microelements in foliar was is more useful than using as application soil. Since use rates are less comparable with soil addition, the same application can be easily obtained and crop reacts with the nutrient application immediately (Zayed *et al*., 2011). Iron and zinc take alot different parts in crop, such as utilization, partitioning and formation of photosynthesis assimilates (Sawan *et al*., 2008). Iron share in very enzymatic activities, such as nitrate reductase, catalase (CAT), peroxidase, ferredoxine, superoxide dismutase (SOD) and cytochromes. Kobraee *et al*., (2011) reported that photosynthesis, symbiosis, nodulation, growth limitation, dry matter, plant nutrient disorder and production were as a result to the lack of zinc and iron. Moreover, electron transportation reactions are needed for zinc and iron. Zinc foliar application at different levels under sandy soil conditions had a significant effect on groundnut growth, yield and its components also seed quality (Gobarah *et al.,* 2006). In soil, when yield extremely decrease crop yield quality may be result for a Zn and Fe deficiency in soils which used as a restricted factor of decreasing (Salwa *et al.,* 2011). Bozoglu *et al.,* (2007) announced that zinc deficiency is a soil common problem in 25 countries. Babaeian *et al*., (2011) found that Zn and Fe deficiencies are common in 30 and 50% of soils, respectively in the world. The authors pretended that low amounts in micronutrient and soil features mainly due to microelements deficiency is which hinder crop roots to obtain them. Also, micronutrients can maintain crop-physiology balance. Moreover, these elements play necessary parts in improving vitamin A, CO_2 flowing out, and resistant system activities (Narimani *et al.,* 2010). So, reduction of these elements can significantly reduce crop's yield, and even can cause stop growing of plant. Generally, amounts of Zn and Fe in soil cannot easily be absorbed by plants although it more than the plant needs. Thus, it is most effective to be used in foliar application way than adding fertilizer to soil.

The aim of this study is to investigate zinc and iron foliar application effects on cowpea plant growth, chemical composition, yield and its components as well as availability of nutrition in soil, all that under phosphorus soil addition effect.

MATERIALS AND METHODS

A field experiment using cowpea as test crop was conducted at the Experimental Farm of Faculty of Agriculture, El-Mansoura University, Egypt, to investigate the effect of zinc and iron foliar application effects on cowpea plant growth, chemical composition, yield and its components as well as availability of nutrients in the soil, all that under phosphorus soil addition effect. At Table 1, soil properties of the experimental site are presented from surface layer.

Table 1. Soil properties of the experimental soil.

Soil properties		Value
Particle size distribution (%)	Coarse sand	5.18
	Fine sand	18.21
	Silt	32.14
	Clay	44.47
	Textural class	Clayey
EC dSm^{-1}(Soil paste extract)		1.08
pH (1:2.5) Soil water suspension		8.12
Saturation percent (SP) %		56.3
Organic matter (OM) gkg^{-1}		16.6
$CaCO_3$ gkg^{-1}		31.8
Potassium chloride extractable N ($mgkg^{-1}$)		52.3
Sodium bicarbonate extractable P ($mgkg^{-1}$)		5.18
Ammonium acetate extractable K ($mgkg^{-1}$)		191.2
(DTPA) extractable Fe (mgkg-1)		2.89
(DTPA) extractable Zn (mgkg-1)		4.83

The experiment was laid out in split plot design with three replicates, assigning twelve treatments consisting of as main plot: three levels of phosphorus (50, 100 and 150% from recommended dose) and as sub plot: four levels of micronutrients foliarly (without, Zn, Fe and Zn+Fe).

The plot area was 20 m^2 and each plot included 6 ridges (75 cm width and 10 m length and 20 cm a part). The planting was done in the 1^{st} week of April. Nitrogen fertilizers was added as ammonium sulfate (20.5% N) at a rate of 119 kg N / ha, phosphorus fertilizers was using as super phosphate (7% P) at the rate of 156 kg P/ ha which added to the soil before planting and as for potassium fertilizers was added as potassium sulfate (40%K) at the rate of 99 kg K/ ha. As for, N and K fertilizers were added in two doses; the first one after one month and the second dose during flowing stage. All fertilization added according to recommendation of the Ministry of Agricultural. All treatments of foliar application (300 and 100 mgL^{-1} for iron and zinc, respectively in chelated form EDTA) were sprayed at flowering stage, three times with 15 days intervals.

The following measurements were recorded:

Vegetative growth:

5 plants sample randomly taken from each plot at 60 days after planting. All plant growth parameters i.e., (plant height (cm), number of leaves/plant, number of branches/plant, fresh weight of leaves/plant (g) and dry weight of leaves/plant (g)) were determined.

Yield and fruit quality:

At harvest time (90 days after planting), No. of pods/plant, No. of seed/pod, 100 seed weight g and fresh seed yield (ton ha^{-1}).

Chemical constituents:

Plant samples were grinded, wet digested after dried at 70^0 C tell constant weight for estimation of; N, P, K, Fe and Zn concentrations. The methods of Mertens, (2005a & b), Agrilasa, (2002), Khazaei *et al*., (2017), respectively were used for the determination.

Method described by Gavrilenko and Zigalova (2003) using for estimated Chlorophyll content in fresh weight.

Total carbohydraties% (Shumaila and Safdar, 2009), fiber according to (AOAC, 2000), Protein content (%): was calculated according to (AOAC, 2000) by multiplying N% = Nitrogen (%) x 6.25.

♠ **Soil analysis:**

- ∗ Mechanical analysis determined according to the methods of Haluschak, (2006).
- ∗ Available N, P and K were determined according to Reeuwijk, (2002).
- ∗ DTPA extractable of Fe and Zn was estimated by Mathieu and Pieltain (2003).

Statistically, data were analyzed by split-Block analysis of variance (ANOVA).The means of three replicates separated by using the least significant difference (LSD) at probability level = 0.05 by using analysis of variance technique by means of CoSTATE Computer Software.

RESULTS AND DISCUSSION

Plant growth parameters:

As shown in Table 2, data illustrated that, the effect of P-fertilization and foliar application of the different micro nutrients, i.e. Zn, Fe and Zn+Fe treatment as well as their interaction on plant growth parameters (plant height (cm), no. of branches/plant, no. of leaves/plant, fresh weight and dry weight (g).

It can be observed that all treatments were increased significantly of vegetative growth as indicated by plant height (cm), no. of branches/plant, no. of leaves/plant, fresh weight and dry weight (g). These effects were more obvious especially at higher concentrations of these treatments 150% RD. The probable reasons might be the stimulating effect of phosphorus on plant processes as phosphorus is a major constituent of plant cell nucleus and growing root tips which helped in cell division and root elongation. P involved in photosynthesis which is directly related with production of root biomass of plant and caused vigorous growth of plants and extensive root system leading to increased growth parameters. These results agree with those of Meena *et al*., (2005), Deo and Khaldewal (2009), Dotaniya *et al.,* (2014) and Balai *et al*., (2017).

Regarding the effect of foliar application with micronutrient on plant growth parameters, foliar application has a significant effect on cowpea growth. Data in Table 2 show that, the highest values of parameters noted with mix of Zn+Fe. Usually, micronutrient-deficiency problems are found in soils. Thus, it is greater to be sprayed cations on the leaves, as foliar application supplie nutrients for plants faster compared with fertilizer application to soil. In addition, the increases in mentioned traits might be due to the building up natural auxin (IAA) and consequently activating the cell division and enlargement as a result to the effect of Zn and Fe (El-Tohamy and El-Greadly, 2007). Similar results in many crops were reported by Heidarian *et al.,* (2011), Salih (2013) and Balai *et al*., (2017). Regarding to the interaction effect between the treatments under study, data also proved that using mix of Zn+Fe under the highest rate of P-fertilization 150% from RD recoded the highest values of parameters under investigation.

Table 2. Effect of foliar application with Zn and Fe on cowpea plant growth parameters under P-fertilization.

Treatments		Plant height cm	No. branches /plant	No. of leaves/ plant	Fresh weight g	Dry weight g
Effect of phosphorus fertilization						
50%		63.03	4.12	24.26	257.88	35.30
100%		68.10	4.61	26.18	278.94	38.00
150%		69.85	4.59	26.38	285.38	39.14
LSD $_{at\ 5\%}$		0.77	0.04	1.16	2.14	0.83
Effect of micro- nutrients application						
0		60.03	3.90	23.00	245.47	33.62
Zn		66.77	4.43	25.43	273.62	37.31
Fe		69.38	4.53	26.69	283.33	38.75
Zn+Fe		71.80	4.90	27.33	293.85	40.25
LSD $_{at\ 5\%}$		0.56	0.29	0.67	1.94	0.70
Effect of interaction						
50% P	0	58.64	3.84	22.57	239.18	32.71
	Zn	62.61	4.03	23.75	257.38	34.75
	Fe	64.48	4.09	25.22	263.60	36.15
	Zn+Fe	66.39	4.52	25.51	271.37	37.57
100% P	0	59.91	3.87	23.22	245.44	33.60
	Zn	67.95	4.59	26.02	278.34	38.04
	Fe	70.99	4.72	27.69	290.14	39.58
	Zn+Fe	73.55	5.26	27.80	301.86	40.79
150% P	0	61.53	3.97	23.20	251.80	34.54
	Zn	69.75	4.68	26.51	285.13	39.13
	Fe	72.67	4.79	27.16	296.27	40.51
	Zn+Fe	75.47	4.93	28.67	308.31	42.38
LSD $_{at\ 5\%}$		0.98	n.s	n.s	3.37	1.22

Chemical composition:

1. Chlorophyll content:

Data presented in Table 3 clearly show the effect of foliar application with micronutrients (Zn and Fe) on chlorophyll content under P-fertilization. The statistical analysis of the data show that applying rates of P-fertilization 50, 100 and 150 P-fertilization from recommended dose significantly affected the chlorophyll content in leaves of cowpea. The data reveal that application of 100% RD produced higher leaves chlorophyll a, b and total than that obtained for the other treatments. Moreover, adding 150% resulted in significant decrease in leaves chlorophyll than the levels of 50 and 100% Rd. The result of chlorophyll affected by phosphorus application may be attributed to its effective role in the chlorophyll pigment synthesis or chlorophyll molecule in the plant tissues. The obtained results are in agreement with those of Deo and Khaldewal (2009), Dotaniya *et al.,* (2014) and Balai *et al*., (2017).

Regarding the plant pigments, data at the same Table showed the effect of foliar application with micronutrient on chlorophyll a, b and total increased significantly with foliar application and the highest values were recorded with using mix of (Zn+Fe) which was (0.702, 0.491 and 1.193 mg/g FW), respectively. This may be due to the participation of Fe in the formation of chlorophyll and Zn enzymatic role in starch formation and in protein synthesis. Thus, leading support to the claim made by El-Tohamy and El-Greadly (2007), Kobraee *et al*., (2011) and Salih (2013).

Chlorophyll a, b and total in leaves of cowpea illustrated in Table 3 as affected by the interaction effect of micronutrient foliar application and P-fertilization. Data clearly show that, chlorophyll content significantly affected with the treatments and the highest values were recorded with foliar application (Zn+Fe) under 100% P-fertilization.

Table 3. Effect of foliar application with Zn and Fe on chlorophyll a, b and total (mg/g) FW under P-fertilization.

Treatments		Chlorophyll a (mg/g FW)	Chlorophyll b (mg/g FW)	Total chlorophyll (mg/g FW)
Effect of phosphorus fertilization				
50%		0.644	0.450	1.094
100%		0.656	0.457	1.112
150%		0.642	0.447	1.089
LSD $_{at\ 5\%}$		0.005	0005	0.007
Effect of micro- nutrients application				
0		0.594	0.411	1.005
Zn		0.628	0.438	1.066
Fe		0.665	0.465	1.130
Zn+Fe		0.702	0.491	1.193
LSD $_{at\ 5\%}$		0.004	0.005	0.007
Effect of interaction				
50% P	0	0.581	0.402	0.983
	Zn	0.630	0.440	1.070
	Fe	0.665	0.465	1.129
	Zn+Fe	0.701	0.492	1.193
100 % P	0	0.593	0.411	1.004
	Zn	0.639	0.445	1.084
	Fe	0.677	0.474	1.151
	Zn+Fe	0.712	0.498	1.210
150 % P	0	0.607	0.420	1.027
	Zn	0.616	0.429	1.045
	Fe	0.652	0.456	1.108
	Zn+Fe	0.691	0.483	1.174
LSD $_{at\ 5\%}$		0.007	0.008	0.011

2. N, P, K, Fe and Zn contents in plant:

Data in table 4 indicate the effect of P-fertilization at rates of 50, 100 and 150% RD and foliar application with Zn and Fe as well as their interactions on the contents of N, P, K %, Fe and Zn (mg/100g).

The average values of N, P, K %, Fe and Zn mg/100g in cowpea plants as affected by soil addition of P-fertilization at rates studied indicated in Table 4. Data, revealed significantly increased in the mean values of these parameters by increasing the rate of P fertilization. It may be due to that P-fertilization plays a role for improving the growth of root system and, consequently enhancing the capacity of root to absorb more nutrients. Also, such increases may be due corresponding increases in available contents of N, P, K, Fe and Zn in the studied soil. These results are simillar to those of Sakara, (2009), Oseni (2009), Benvindo *et al.,* (2014).

Data in Table 4, clearly show that foliar application with micronutrient in individual or mix form significantly affected in uptake of nutrients by leaves of cowpea plant. The highest mean values of N, P, K %, Fe and Zn mg/100g in cowpea plants were recorded by spraying plant with mix of (Zn+Fe). This result could be due to sharing of foliar micronutrients such as iron and zinc, which iron in the formation of chlorophyll (Kolota and Osinska, 1999). Zn plays a role in plant enzymes. Also, it has an essential element which contain in a functional structural or many enzymes or regulatory cofactor and for protein synthesis, photosynthesis, the synthesis of auxin, cell division, and sexual fertilization. Also, zinc plays a special role in synthesizing proteins, RNA and DNA. It has been discovered that iron is activator of a lot of enzymes and it assume vital part in plant growth and production, including chloroplast development, protein synthesis and chlorophyll synthesis. Deb *et al*., (2006), Bhuiyan *et al*., (2008), Pingoliya *et al*., (2014) and El-Azab (2016).

The result in the same Table, illustrated that the interaction effect between treatments under investigation, significantly affect the average values of N, P, K, Fe and Zn concentration by adding different forms of micronutrients regardless of rate of the applied P fertilization. The highest values of N, P, K, Fe and Zn contents were generally attained in plant treated with foliar application of the mix micronutrient treatment (Zn+Fe) grown under 150% RD from P-fertilization.

Table 4. Effect of foliar application with Zn and Fe on nutrient contents of cowpea leaves under P-fertilization.

Treatments		N %	P %	K %	Fe (mg/100g)	Zn (mg/100g)
Effect of phosphorus fertilization						
50%		4.11	0.266	1.33	8.64	18.43
100%		4.44	0.315	1.73	8.84	18.88
150%		4.55	0.329	1.83	9.02	19.11
LSD at 5%		0.05	0.004	0.24	0.08	0.24
Effect of micro- nutrients application						
0		3.92	0.236	1.21	8.26	17.84
Zn		4.36	0.301	1.65	9.28	18.39
Fe		4.52	0.326	1.69	8.64	19.69
Zn+Fe		4.69	0.351	1.97	9.15	19.30
LSD at 5%		0.04	0.005	0.16	0.04	0.16
Effect of interaction						
50% P	0	3.83	0.222	1.11	8.11	17.65
	Zn	4.10	0.265	1.41	9.02	17.95
	Fe	4.20	0.281	1.17	8.53	19.16
	Zn+Fe	4.33	0.296	1.62	8.89	18.94
100% P	0	3.91	0.237	1.18	8.29	17.84
	Zn	4.43	0.313	1.73	9.27	18.49
	Fe	4.62	0.340	1.92	8.65	19.84
	Zn+Fe	4.81	0.371	2.09	9.15	19.36
150% P	0	4.01	0.250	1.32	8.38	18.04
	Zn	4.55	0.324	1.82	9.56	18.72
	Fe	4.73	0.356	1.98	8.75	20.08
	Zn+Fe	4.92	0.387	2.20	9.41	19.59
LSD at 5%		0.06	0.009	0.28	0.07	0.29

Quality parameters:

Data presented in Table 5 show the effect of treating cowpea plants with 50, 100 and 150% P-fertilization from recommended doses, different microelements and their interactions on C.protien, T.carbohydraties and C. fiber of cowpea plant.

It is clear from the presented data that treating cowpea plants with P-fertilization as soil addition significantly affected C.protien, T.carbohydraties and C. fiber. Parameters increased with increasing P-fertilization, which recorded the highest values with 100% RD, then decreased with high level. It could be related to increasing in nodulation then increasing content of N or protien in legumes as a result of phosphorous fertilization. Magani and Kochinda (2009) reported that crude protein content of cowpea seed was increased significantly (P d" 0.01) with increased rate of P (0, 37.5, and 75 kg ha^{-1}). Kumar *et al.,* (2012) reported that ether extract and ash, crude fiber content were increased with each increment of P_2O_5 levels, in forage cowpea. Jha *et al*., (2014) observed that the application of 80 kg P_2O_5 ha^{-1} recorded significantly higher crude fiber yield (6.1 q ha^{-1}).

Table 5. Effect of foliar application with Zn and Fe on cowpea quality parameters under P-fertilization.

Treatments		C. protien %	T. carbohdraties %	C. fiber%
Effect of phosphorus fertilization				
50%		24.50	59.82	4.77
100%		24.79	60.25	4.91
150%		24.43	59.83	4.75
LSD at 5%		0.09	0.18	0.03
Effect of micro- nutrients application				
0		23.36	58.37	4.26
Zn		24.17	59.43	4.64
Fe		24.98	60.64	5.00
Zn+Fe		25.79	61.44	5.36
LSD at 5%		0.11	0.14	0.05
Effect of interaction				
50% P	0	23.10	58.05	4.14
	Zn	24.19	59.34	4.64
	Fe	24.96	60.62	4.98
	Zn+Fe	25.76	61.28	5.33
100% P	0	23.35	58.36	4.26
	Zn	24.45	59.94	4.75
	Fe	25.26	60.97	5.12
	Zn+Fe	26.09	61.73	5.52
150% P	0	23.62	58.69	4.38
	Zn	23.86	59.02	4.53
	Fe	24.72	60.32	4.89
	Zn+Fe	25.52	61.31	5.21
LSD at 5%		0.19	0.24	0.09

Results in Table 5 illustrated the effect of foliar spray with different microelements, i.e. Zn and Fe in comparison with untreated plants on C.protien, T. carbohydraties and C. fiber of cowpea plant. It is clear from the data that spraying cowpea plants with all tested nutrient enhanced significantly all studied traits based on different microelement. Parameters were increased with foliar application of mixed micronutrient treatment (Zn+Fe). The increase in protein content due to zinc addition might be attributed to its involvement in nitrogen metabolism of plants. Chavan *et al.* (2012) stated that great values of maximum protein content in cowpea grains reported as a result of application 40 kg ha^{-1} zinc over 0 and 20 kg zinc. Applied zinc to crops were more powerful than others and had a huge growth because zinc had a vital part in stabilizing DNA and RNA structure, and involves in biosynthesis of growth promoting hormones such like gibberellins and IAA (Mousavi, 2011). Kumar *et al.* (2002) resulted an increase nodulation, protein content, nutrients uptake and protein yield with application of zinc at 9.0 kg ha^{-1} over control in cowpea. Safak *et al.* (2009) stated that zinc is an activator of many enzymes involved in photosynthesis, cell division and elongation. Thus crud fiber, crude protein and zinc concentration significantly were affected by zinc fertilization. Yadav *et al.,* (2002) and Pingoliya *et al*., (2014) reported that with the application of 30 kg P_2O_5 ha^{-1} and 4 kg Fe ha^{-1}, the protein content in seeds increased significantly comparing with their lower levels in mung bean.

It is evident from these results that, generally, such interaction treatments had a promotive effect on C.protien, T.carbohydraties and C. fiber of cowpea plants, the interaction between foliar spray with microelements and soil addition of P-fertilization. The highest mean values of C.protien, T.carbohydraties and C. fiber were recorded with foliar application of Zn and Fe chelating, respectively under100% P-fertilization from recommended doses.

Yield and its components:

No. of pods/plant, No. of seed/pod, 100 seed weight (g) and seed yield (Kg/fed) of cowpea plants were recorded in Table 6 as affected by P-fertilization and micro elements as well as its interaction. The yield and its component parameters were increased significantly in response to rate of 150% RD from P-fertilization. The increase in seed yield due to phosphorus application is attributed to source and sink relationship. It appears that greater translocation of photosynthates from source to sink (seed) have increased the seed yield. It might also be due to improvement in yield attributes which ultimately increased the seed yield as evident by existence in strong positive correlation between seed yield and pods per plant, seeds per pod and 100-seed weight (Table 6). These findings clearly suggest profound role of phosphorus fertilization in exploiting inherent potential of vegetative and reproductive growth which ultimately resulted in increased productivity of cowpea crop (Balai *et al.,* 2017). These results are in line with that reported by Kumar *et al.,* (2012), Bhavya *et al.* (2014), Dixit *et al.* (2014) who reported that application of 60 kg P_2O_5 ha^{-1} gave significantly higher green fodder yield (42.9 t ha^{-1}) of sorghum + cowpea than without phosphorus.

Regarding the effect of micro elements on No. of pods/plant, No. of seed/pod, 100 seed weight (g) and seed yield (Kg/fed) of cowpea plants, at the same Table 6, the mean values of the parameters for cowpea plant were significantly increased with the foliar application by some microelements, i.e. Ze & Fe treatment. No. of pods/plant, No. of seed/pod, 100 seed weight (g) and seed yield (Kg/fed) of cowpea plants and the increment in yield parameters brought by the mix treatment of micronutrient (Zn+Fe) comparing with the untreated treatment. The increase in seed yield due to zinc and iron application could possibly be due to the enhanced synthesis of carbohydrates and protein and their transport to the site of seed formation (Mali *et al*., 2003). These results are agree with those of Kumawat *et al.,* (2006), Sahu *et al.,* (2008), Kumar *et al*., (2009), Nasri *et al*. (2011) and Balai *et al.,* (2017). Also, Mevada *et al*., (2005) conducted a field experiment on urdbean to investigate the effect of the application of micronutrient (Zn, B, Mo & Fe) and said that under the application of chelated Fe obtained maximum grain yield over control.

Regarding the interaction effect between the above treatments, data in Table 6 also showed that; using (Zn+Fe) + 150% RD from P-fertilization for the plants gave the highest mean values of No. of pods/plant, No. of seed/pod, 100 seed weight (g) and seed yield (Kg/fed) of cowpea plants, while 50% RD from P-fertilization connected with the lowest one.

Table 6. Effect of foliar application with Zn and Fe on cowpea yield and its components under P-fertilization.

Treatments		No. of pods/plant	No. of seed/pod	100 seed weigh (g)	Seed yield ton/ha
Effect of phosphorus fertilization					
50%		19.41	7.55	15.98	2.34
100%		21.02	8.17	17.23	2.54
150%		21.50	8.39	17.64	2.58
LSD at 5%		0.75	0.11	0.16	0.05
Effect of micro- nutrients application					
0		18.39	7.20	15.20	2.25
Zn		20.67	8.04	16.89	2.47
Fe		21.21	8.30	17.53	2.56
Zn+Fe		22.31	8.60	18.19	2.66
LSD at 5%		0.63	0.10	0.17	0.04
Effect of interaction					
50% P	0	18.26	7.04	14.95	2.16
	Zn	19.37	7.51	15.87	2.33
	Fe	19.54	7.72	16.36	2.39
	Zn+Fe	20.48	7.93	16.76	2.46
100% P	0	18.09	7.15	15.09	2.31
	Zn	21.17	8.18	17.19	2.50
	Fe	21.72	8.53	17.89	2.62
	Zn+Fe	23.12	8.81	18.75	2.73
150% P	0	18.82	7.40	15.56	2.28
	Zn	21.48	8.44	17.61	2.59
	Fe	22.38	8.66	18.34	2.68
	Zn+Fe	23.32	9.07	19.06	2.79
LSD at 5%		1.10	0.17	0.29	0.09

Soil nutrient availability:

Data illustrated in Table 7 indicate that, N, P, K, Zn and Fe $mgkg^{-1}$ were significantly affected the average values of above parameters in the soil after planting cowpean plant.

It is obvious that; available P, Zn and Fe $mgkg^{-1}$ in the soil were recorded the highest mean values with using 100% from recommended dose as P-fertilization, while the lowest values of available N and K $mgkg^{-1}$ were realized for the same treatment.

Referring the effect of plant growth regulators data in Table 7 show that; the average values of available P, Zn and Fe $mgkg^{-1}$ in the soil were significantly increased under any forms. The increase in available P, Zn and Fe could be due to the lower soil pH resulting from the use of super phosphate in the soil experiment which have been due to slow release of the sulfate after its application to soil improving soil structure, chemical properties and increased the availability of essential plant nutrients such as N, P and K also, some micronutrients such as Fe and Zn. Also, exudation of carboxylates from cowpea roots as legumes, these acids were capable of lowering the soil pH (Tunya *et al*., 2014).

Within the foliar application; data in Table 7 appear a superiority effect of mixing micronutrient treatment (Zn+Fe) on the mean values of available P, Zn and Fe $mgkg^{-1}$, while high availability of N and K recorder with the untreated plant. These results are similar to those of El-Fouly *et al*. (2011), El-Saady

(2012) and Faizy *et al.,* (2017). Moreover, the interaction between treatments significantly affected on soil nutrient availability and the highest mean values recorded under mix of micronutrient treatment (Zn+Fe) under phosphorus fertilization.

Table 7. Effect of foliar application with Zn and Fe on availability of N, P, K, Fe and Zn ($mgkg^{-1}$) in the studied soil under P-fertilization.

Treatments (soil)		N $mgkg^{-1}$	P $mgkg^{-1}$	K $mgkg^{-1}$	Fe $mgkg^{-1}$	Zn $mgkg^{-1}$
Effect of phosphorus fertilization						
50%		66.60	6.19	224.08	1.55	3.99
100%		60.86	7.69	206.95	1.81	4.39
150%		59.11	8.18	201.80	2.01	4.63
$LSD_{at\ 5\%}$		0.01	0.04	0.40	0.02	0.01
Effect of micro-nutrients application						
0		69.69	5.22	233.53	1.12	3.32
Zn		62.42	7.24	212.63	2.32	3.98
Fe		59.67	8.04	203.03	1.55	5.21
Zn+Fe		56.97	8.91	194.57	2.17	4.84
$LSD_{at\ 5\%}$		0.03	0.03	0.23	0.03	0.03
Effect of interaction						
50% P	0	72.14	4.77	237.50	0.97	3.09
	Zn	66.29	6.19	224.30	2.03	3.76
	Fe	64.87	6.65	219.90	1.35	4.67
	Zn+Fe	63.09	7.13	214.60	1.86	4.45
100% P	0	69.51	5.18	233.70	1.13	3.32
	Zn	61.34	7.54	209.50	2.34	3.98
	Fe	57.93	8.41	197.40	1.58	5.36
	Zn+Fe	54.65	9.63	187.20	2.19	4.90
150% P	0	67.42	5.70	229.40	1.27	3.54
	Zn	59.62	7.98	204.10	2.58	4.21
	Fe	56.20	9.06	191.80	1.73	5.59
	Zn+Fe	53.18	9.98	181.90	2.46	5.16
$LSD_{at\ 5\%}$		0.06	0.05	0.43	0.05	0.06

CONCLUSION

Lately the work linked to plant nutrition on growth, yield, chemical and quality of cowpea has come to derivation that macro nutrients in foliar way under P-fertilization plays an vital part in the production of good crop and higher yield. The above results showed that the vegetative growth, yield, chemical and quality of cowpea plants were increased by soil addition of P-fertilization and foliar application of micronutrients. The treatment of P 100% and 150% RD + mix of micronutrient treatment (Zn+Fe) gave highest results of growth and yield components of cowpea.

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التأثير المتكامل للتسميد الورقي للحديد، الزنك ومعدلات من السماد الفوسفاتي على نمو ومحصول اللوبيا

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أجريت تجربة حقلية فى مزرعة كلية الزراعة جامعة المنصورة. لدراسة تأثير إضافه الزنك و الحديد فى صورة فردية أو مخلوطة رشاَ على النمو الخضرى والمحتوي الكيميائى، جودة الحبوب والمحصول لنبات اللوبيا ومكوناته بالإضافه إلى محتوى التربة من العناصر بعد الزراعة كل ذلك تحت تأثير مستويات مختلفة من التسميد الفوسفاتى. صممت التجربة فى قطاعات منشقة في 3 مكررات محتوية على 3 مستويات من التسميد الفوسفاتى المعدني (50، 100، 150% من الموصي به) كمعاملات رئيسية و 4 صور من التسميد الورقي بالعناصر الصغرى (كنترول ، حديد، زنك ، خليط من الحديد و الزنك) كمعاملات تحت منشقة. بالنسبه لتأثير التسميد الفوسفاتى أظهرت النتائج زيادة معنوية فى كل من النمو الخضرى (طول النبات، عدد الأفرع، عدد الأوراق)، المحصول ومكوناته (عدد القرون، عدد البذور فى القرن، وزن 100 حبه، محصول البذور) بالإضافه إلى المحتوى الكيميائى (محتوى الكلوروفيل، النسبة المئوية للنيتروجين، الفوسفور، البوتاسيوم، الزنك و الحديد) وكذلك صفات الجودة من (البروتين، الكربوهيدرات، الألياف). هذه الزيادة كانت مع التسميد بالفوسفور بأعلى مستوى 150% من الموصي به ماعدا مع محتوى النبات من الكلوروفيل وصفات الجودة ، ومحتوى التربة من الفوسفور والحديد والزنك كانت مع التسميد بالفوسفور 100% من الموصي به بينما عند نفس المستوى أظهر أقل نتيجة فى محتوى التربة من النيتروجين والبوتاسيوم بالملليجرام/كجم. أما بالنسبه لتأثير الرش بالعناصر الصغرى فكانت أعلى النتائج لكل الصفات عند الرش بمخلوط من الحديد والزنك مقارنة بالنباتات الغير معاملة. أظهر تأثير التداخل بين المعاملات تحت الدراسة وجود زيادة عند الرش بمخلوط العناصر الصغرى تحت المستوى العالى من الفوسفور 150% ماعدا مع محتوى النبات من الكلوروفيل وصفات الجودة ، ومحتوى التربة من الفوسفور والحديد والزنك كانت مع التسميد بالفوسفور 100% و الرش بالعناصر الصغرى بينما نفس المعاملات سجلت أقل القيم لكل من محتوى التربة من النيتروجين والبوتاسيوم.